TEMPORAL VARIATIONS OF THE GRAVITY FIELD AND EARTH PRECESSION-NUTATION

G. BOURDA, N. CAPITAINE
SYRTE - UMR8630/CNRS, Observatoire de Paris
61 avenue de l'Observatoire - 75014 Paris, FRANCE
e-mail: Geraldine.Bourda@obspm.fr

1. INTRODUCTION

Due to the accuracy now reached by space geodetic techniques, the temporal variations of a few Earth gravity field coefficients can be determined. Such variations result from Earth oceanic and solid tides, as well as from geophysical reservoirs masses displacements and post-glacial rebound. They are related to variations in the Earth's orientation parameters through their effect in the inertia tensor. We use (i) time series of the spherical harmonic coefficients C_{20} ($C_{20} = -J_2$) of the geopotential and also (ii) ΔC_{20} models for removing a part of the geophysical effects. The series were obtained by the GRGS (Groupe de recherche en Géodésie Spatiale, Toulouse) from the orbitography of several satellites (e.g. LAGEOS, Starlette, CHAMP) from 1985 to 2002 (Biancale et al., 2000). In this preliminary approach, we investigate how these geodesic data can influence precession-nutation results.

2. DATA AND METHOD

From the C_{20} variation series, we can derive the corresponding variations of the dynamical flattening H, according to : $\Delta H = -M \ R_e^2 \ \frac{\Delta C_{20}}{C}$, where M is the mass of the Earth, R_e its mean equatorial radius and C its principal moment of inertia. The ΔH series obtained in this way are mostly composed of an annual, semi-annual and 18.6-year terms. In order to investigate the influence of the variations in dynamical flattening on the precession-nutation, we integrate the following precession equations (Williams 1994, Capitaine et al. 2003 = P03) based on the observed ΔH series :

$$
\begin{aligned}
\sin \omega_A \frac{d\psi_A}{dt} &= (r_\psi \ \sin \epsilon_A) \ \cos \chi_A - r_\epsilon \ \sin \chi_A \\
\frac{d\omega_A}{dt} &= r_\epsilon \ \cos \chi_A + (r_\psi \ \sin \epsilon_A) \ \sin \chi_A
\end{aligned}
\tag{1}
$$

where r_ψ and r_ϵ are the total contributions to the precession rate, respectively in longitude and obliquity, depending on the factor H.

3. COMPUTATION AND RESULTS

We use the precession equations (1) and the software GREGOIRE (Chapront, 2003), together with the ΔC_{20} data, to compute the effects in precession nutation. We find differences in the coefficients of the polynomial development of the precession angle ψ_A, depending on the ΔC_{20} contribution and the J_2 rate implemented (J_2 rate = $\dot{J}_2$). The results are composed of a polynomial part and a periodic part (i.e. Fourier and Poisson terms) discussed in the next paragraph. The effect due to the J_2 rate (i.e. effect on the t^2 term of ψ_A) can be taken into

account using a series from 1985 to 1998 (Bourda and Capitaine, 2004). In Table 1, our results rely on ΔC_{20} data from 1985 to 2002 and then do not take into account this effect.

Table 1: Polynomial expression for ψ_A (up to degree 3) : (1) P03 and (2) Difference of our computation (influence of the ΔC_{20} *residuals*, obtained with various H constant parts) with respect to P03.

		t	t^2	t^3
(1) *P03*		5038".481507	-1".079007	-0".001140
(2) Difference of our	geodetic H constant part	0".413188	-0".001667	0".2 10^{-6}
computation w.r.t P03	VLBI H constant part	0"	-0".001579	0".5 10^{-6}

Table 2: Periodic contribution for the t^0 term of ψ_A, for different ΔC_{20} contributions; in microarcseconds.

	Period	cos	sin
Residuals	Annual	-1	1
	Semi-annual	-	1
Solid Earth tides	18.6-yr	-2	120
TOTAL	18.6-yr	4	105

4. DISCUSSION

The precession rate (i.e. term in t in the ψ_A development) derived from the C_{20} obtained by space geodetic techniques is smaller than the one obtained by VLBI (see Table 1). The difference is about 400 mas/c, i.e. $\simeq 10^{-4} \times$ the precession rate value (this corresponds to a constant part of $-2.6835\ 10^{-7}$ in the H value). Dehant and Capitaine (1997) already mentioned such a discrepancy relative to the IAU 1976 precession. Considering an error of about 10^{-10} in the ΔC_{20} data, we deduce an error of about 0.5 mas/c in the precession constant, which means that the difference obtained above is significant. In the future, several causes for this discrepancy will be investigated, such as the effect of the violation of hydrostatic equilibrium.

Then, the H variations coming from the *residuals* (i.e. ΔC_{20} data without atmospheric, oceanic tides or solid Earth tides ΔC_{20} models) observed by space geodetic techniques involved effects on the precession angle of about 1 μas or less (see Table 2). We also observed that the oceanic and atmospheric contributions were negligible. The principal periodic change, is due to the ΔC_{20} solid Earth Tides 18.6-yr variation, and is about 120 μas (in sine).

For further studies, the Earth model has to be improved by considering (i) a refine Earth model, with core-mantle couplings and (ii) a reliable J_2 rate value.

5. REFERENCES

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